WORLD SKILLS ROBOTICS 2016

Blinkbox v12 Project Portfolio

Abstract

Blinkbox v12 is a four wheeled robot with Ackerman steering. It has been designed to be as versatile and compact as possible whilst still being able to efficiently navigate autonomously.

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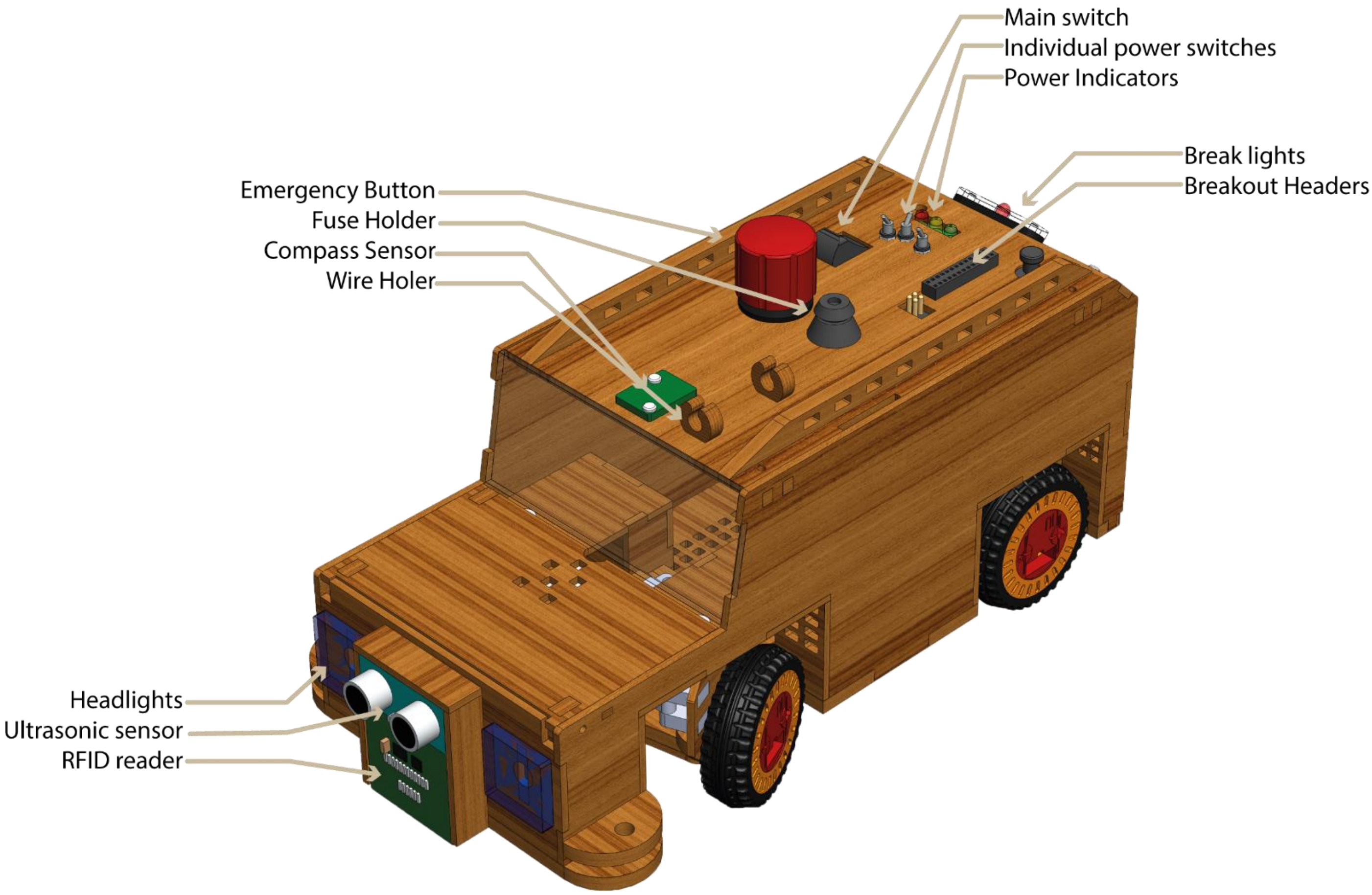
1 WORLD SKILLS PROJECT PORTFOLIO – TEAM BLINK

1.1 GENERAL DESCRIPTION

Blinkbox v12 is a four-wheeled autonomous robot with Ackerman steering. It has been designed to be as versatile and compact as possible while being able to navigate using path planning and obstacle detection algorithms. Blinkbox measures approximately 300x130x150 i.e. (length x width x height), and is fitted with line sensors, bump sensors, a RFID reader, a distance sensor and a compass module. There's also an extension port for interfacing with external peripherals e.g. Serial/I2C Communication Dongles (like Bluetooth dongles, etc.), an arm attachment, etc.



Prior to the competition a map with the routes to various locations will be stored in Blinkbox's memory as "*.MAP*" files using the appropriate naming format i.e. (routeName = startLocation + "_" + endLocation + "*.MAP*"). During its run it will query its map for the stored path to the items location, execute the path directions while checking of obstacles, stall and skid. If any obstacle is encountered, Blinkbox will try to resolve it using the hard coded instructions stored in its memory. On successful arrival at its destination if it is not its home destination, Blinkbox will read the item's RFID, then query its map for the next path using its current location and the item's RFID as the key. Note: *This is valid because each item's drop off location will be its radio frequency ID*.

```
char* objectsRfid[20]; getObjectsRfid( objectsRifd );
String objectsId = String(objectsRfid);
String nextLocationKey = currentLocation[0:5] + "_" + objectsId[0:5];
```

Note: Just for illustration

Due to Blinkbox's locomotive design, most sensors are not as adjustable but nevertheless all of its sensors, and actuators are carefully and accurately placed in locations that are best suit for all key case scenarios that may be encountered during its run. Among these include:

A PRECISE BONNET DEPTH

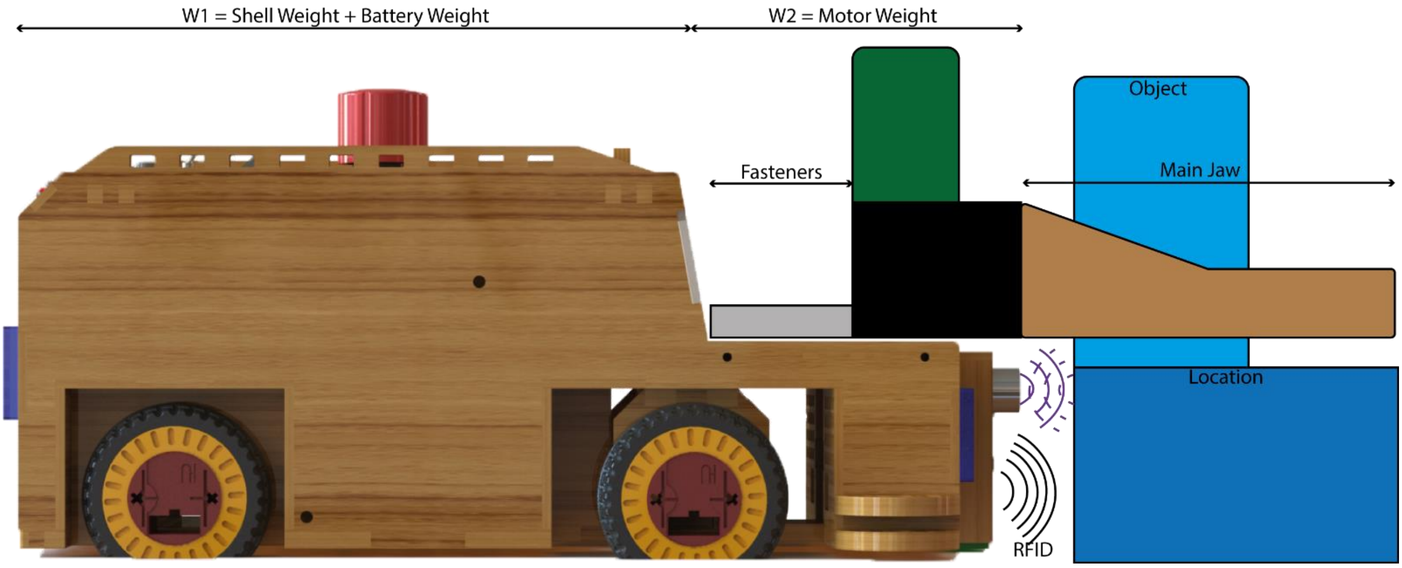
- **The bonnet depth was chosen to ensure that the weight of the arm attachment is completely balanced by the weight of the battery. This ensures that the energy from all the wheels are used, significantly improving handling, while increasing power efficiency.**

- **The bonnet depth also ensures that Blinkbox is not longer than required, exposing only the jaws of the grippers. This reduces Blinkbox's turning radius.**

And,

A PRECISE VERTICAL ARRANGEMENT OF THE SENSORS IN THE FRONT SENSORS BAY

- **The height of the distance sensor ensures that the objects distance is read directly from the location's surface, while the RFID reader has a card detect mechanism which is used to verify the location.**



Blinkbox's locational algorithm is relational, and will be recalibrated often. Various recalibration routines can be carried out using its line, bump, distance, and quadrature sensors. Its rotational position however can be determined in real time from its compass module. Hence, its displacement and rotational deviation from the home location is known.

Blinkbox can detect and avoid various obstacles such as collisions and bad terrains. Obstacles such as obstructions caused by objects are detected by its distance sensor. When this is detected and its current path has been tagged with avoid collisions, it checks if the object will interfere with its current route, if a collision is predicted it plans an alternate route. This alternate route will rendezvous with its main route avoiding a collision with the obstacle. This route is re-calculated when more obstacles are detected. Its deviation from every route is stored, if it can't find a way through the obstacles or if the specified time for the journey has elapsed, it raises an alarm, aborts the mission and attempts the next mission after retracing its steps to its home position (Note: The time specified is dynamic as it must compensate for alternate routes). However, if there is no avoid collisions tag, cruise control would be enabled. This is useful when it might be time-consuming to avoid every obstacle encountered. In this scenario Blinkbox would regulate its wheel power to ensure that its speed is maintained enabling it to drive through movable obstacles. When using this technique most robots tend to change their path due to collisions. However, this problem has been tremendously mitigated, because Blinkbox actively corrects for side deviations.

```
float sideError = myWheel.getLeftDisplacement() – myWheel.getRightDisplacement();
//if (sideError > 0) then car is deviating to the right else if < 0 car is deviating to the left else car is not deviating;
```

Note: Just for illustration

More complicated obstacles can also be detected, Blinkbox roams its terrain assuming that its suitable, if it detects otherwise an alarm is raised and the stored emergency instructions are executed. The terrain is judged as bad, if Blinkbox detects a stall in both directions (forward and backward), or a skid beyond the allow skid threshold. A skid is detected when the encoders report a valid wheel speed and the accelerometer detects little or no acceleration. Likewise, a stall is detected when power is supplied to the wheels and little or no speed is detected by the encoders.

1.2 Mechanical Information

Robot Hardware	Description	
Chassis	Configuration	Frame-full chassis
	Material	MDF
	Fastener	Glue
Wheels	Configuration	All wheels drive with left and right quadrature encoders
	Brand	HUB-ee wheels
	Speed	MAX SPD: 400 mm/s AVERAGE OPERATING SPD: 270 mm/s
	Power	3000 x10^{-3} hp
Steering Mechanism	Configuration	Ackerman - shoulder elbow configuration
	Steer type	Front steer
	Steer Speed	500ms per 60deg #Surface Dependent
	Steer Torque	10
	Turn radius	250 mm

1.3 Electrical and Electronic Information

Robot Electronics	Description	
Controller	Configuration	Dual Core – Master and Slave Configuration
	Controller Type	Atmega328p-pu
	Speed	16Mhz
	Computing Mode	Parallel
	Functions Execution Mode	Linear, and Multitasking using a function queue Note: The function is FIFO based (no priority).
Programming	Configuration	Dual serial bus
	Interface	FTDI
	IDE	Arduino
Communication	External communication can be achieved by interfacing external dongles to the expansion port. Blinkbox will support any communication dongle that interfaces either through serial (9600baud – 115200baud) or I2C. Please note that the necessary code to handle this must be implemented.	
Expansion Port	The expansion port exposes interface ports of other peripherals to be attached.	
Memory	Configuration	Controller_1 – INTERNAL EEPROM Controller_2 – INTERNAL EEPROM Controller_2 – SD CARD Note: The EEPROM is expandable through I2C
	EEPROM	1024 bytes – Used for system functions
	SD CARD	8gb – Used for log files, maps, etc.
Protection	Polarity	One-way polarity based battery connectors used Diode protection
	Short-circuit	2A rated fuse in-line with Vin <main>
	EMI	There isn't any real EMI protection built-in due to budget restrictions. However, all high frequency device has been isolated with individual voltage clamping, reverse polarity protection and voltage ripple feedback protection circuitry.
	Power	Emergency switch Main power switch Individual voltage switches
	Fire suppression	Fire bag included with battery All cables are within required current ratings
	Pull to start	
Cooling	Fan	Power - 0.8 w @ DC 7.5V Run time – At specific time intervals
	Passive Cooling	All wheels are passively cooled

Lights	Configuration	Left and right independent control
	Colour	Blue
	Power	20mA @ DC 5V
Horn	Configuration	Single horn
	Operating Voltage	DV 5V
	Noise Level	95 db
Distance Sensor	Configuration	Front only
	Brand	HC-SR04 4 pin Ultrasonic range finder
	Power	15mA @ DC 5V
	Frequency	40Hz
	Range	20mm – 4000 mm
	Angle	15deg
	Pole Freq.	1Hz
Compass Module	Configuration	Single – top centred
	Brand	CMPS11
	Interface	I2C
	Power	25mA @ DC 5V
Quadrature Encoders	Configuration	Left and right rear wheels only
	Brand	HUB-ee
	Resolution	2.9mm per interrupt
Line Sensors	Configuration	5 Linear line sensors
	Brand	LSS05
	Power	20mA @ DC 5V
	Range	(10-40) mm
RFID Reader	Configuration	Front only
	Brand	SL030
	Voltage	DC 2.5 – 3.6 V
	Frequency	13.56MHz
	Protocol	ISO14443A
	Tag supported	MIFARE Ultralight, NTAG203, MIFARE Mini, MIFARE Classic 1k, MIFARE Classic 4K, FM11RF08
	Interface	I2C
Power rating	Configuration	3c Lipo 5200mAh @ DC 12.6 V
	Average current consumption	800mA @ DC 12.0 V
	Short-circuit cut off current	2A
	Average Battery Life	6.25 hours
	Max Power	2A @ DC 12.0 V

1.4 On Board Processors and Programming Language

Blinkbox v12 is fitted with two atmega328p-pu micro controllers, they both communicate with each other using I2C. One of the controllers handles all the low-level instructions like spinning the wheels, and steering the robot, while the second controller handles all the path planning, task scheduling, and obstacle detection. The latter issues commands to the prior on what actions to take. Once every twenty seconds a check-up handshaking is done, if any of the micro controllers fails to respond during the handshaking routine, the working controller logs and saves its data in memory, then restarts both itself and the faulty controller. Both controllers have been programed using the Arduino IDE (C/C++). Updates and Information about the project including all the CAD/CAM files, schematics, and programs can be found at https://github.com/chibike/WORLDSKILL_ROBOTICS_2016. More queries and questions can be sent to Okpaluba Chibuike CO607@live.mdx.ac.uk, or Manandhar Raj RM1348@live.mdx.ac.uk.

1.5 Equipment Used

- **Soldering iron**
- **Solder sucker**
- **Solder wig**
- **Multimeter**
- **Laser Machine**
- **Computing Workstations**
- **Miscellaneous Machines** E.g. Pillar drills, etc.
- **Glue Gun**
- **Mathematical and Measuring Set**
- **Others**

1.6 Software Used

CAD/CAM	PROGRAMMING	PDF
Solidworks CAD	**Arduino IDE**	**Adobe Illustrator**
Photoview 360	**Python**	**Adobe Photoshop**
2d Design	**GitHub**	**Microsoft Word**
NI LabVIEW		**PDF Editor**
Eagle CAD		
NI Multism		

1.7 Project Plan – Task Distribution

Task	Member/Members Responsible
Electronics/Circuit Design	Okpaluba Chibuike, Manandhar Raj
Electronics/Circuit Manufacture and Debugging	Okpaluba Chibuike, Manandhar Raj
Electronics/Circuit Graphics Design i.e. pin mappings, etc.	Okpaluba Chibuike, Manandhar Raj
Mechanical/Structural Design	Okpaluba Chibuike, Manandhar Raj
Mechanical/Structural Manufacture	Okpaluba Chibuike, Manandhar Raj
Body/Structural Priming and Painting	Okpaluba Chibuike, Manandhar Raj
Body & Electronics Assembly	Okpaluba Chibuike, Manandhar Raj
Programming	Okpaluba Chibuike, Manandhar Raj
General Debugging and Maintenance	Okpaluba Chibuike, Manandhar Raj

1.8 Project Plan – Task Schedule

Task	Jun	Jul	Aug	Sep	Oct	Nov
Electronics/Circuit Design	★					
Electronics/Circuit Manufacture and Debugging	★	★	★	★		
Electronics/Circuit Graphics Design	★	★				
Mechanical/Structural Design	★					
Mechanical/Structural Manufacture	★					
Body/Structural Priming and Painting	★					
Body & Electronic Assembly	★					
Programming		★	★	★	★	★
General Debugging and Maintenance	★	★	★	★	★	★

1.9 Bill of Materials

Part Name	Quantity	Source	Price £
MDF (600x1200x3) mm	1	University Store	3.75
MDF (600x400x6) mm	1	Workshop	N/A
Nylon Dowels (50x8) mm	2	University Store	N/A
Acrylic (300x100x3) mm	1	Workshop	N/A
Acrylic (300x100x2) mm	1	Workshop	N/A
Fasteners	50+	University Store	N/A
Glue Wood/Acrylic	100ml	Workshop	N/A
Hot Glue	2 Sticks	University Store	N/A
Aluminium Tape (200x20) mm	1	University	N/A
11.1v Lipo Battery @ 5500mah	1	Amazon	20.99

T-Trees 80W Battery 6A Charger/Discharger/Balancer	1	Amazon	27.77
Battery Tester/Low voltage buzzer	1	Amazon	1.40
AGM XT60 Female to Male Deans T Connector Adapter	1	Amazon	1.60
RHX XT60 Bullet Connectors	5 pairs	Amazon	2.83
Lipo Storage Fire Bag 64mm x 50mm x 125mm	1	Amazon	5.56
Hubbe Wheels	4	University	N/A
Wires (200x1) mm	10	University	N/A
Wires (200x2) mm	2	University	N/A
Solder	50m	University	N/A
3pcs 20cm Multi-coloured 40-pin Breadboard Jumper wires ribbon cables	2	Amazon	11.98
10kg Hx12k Servo	1	University	N/A
Adjustable Voltage Regulator	1	Amazon	6.72
HC-SR04 Distance Sensor	1	Amazon	1.00
SLO30 RFID Sensor	1	University	N/A
CMPS11 Compass Sensor	1	University	N/A
LSS05 Line Sensor Module	1	University	N/A
Atmega328p-pu	2	University	N/A
74HC595 Shift register	1	Amazon	1.00
H Bridge L9110	1	Amazon	3.125
SD card reader	1	University	N/A
SD card 8gb	1	University	N/A
DC 12v Fan	1	University	N/A
PCB Dual Sided Board 60x80 mm	2	Amazon	3.00
Strip Board 60X10 mm	1	University	N/A
2 Pole 5mm Pitch PCB Mount Screw Terminal Block 8A 250v	7	Amazon	0.4795
Led/Diodes	10 Leds, 5 diodes	University	N/A
Capacitors		University	N/A
Resistors		University	N/A
Push Buttons			
Fuse Holder	1	University	N/A
2A Fuse	1	University	N/A
Emergency Button	1	University	N/A
Main Switch	1	University	N/A
Toggle Switch	3	University	N/A
Micro Switch	3	University	N/A
HC-05 RS232 30ft Bluetooth RF Transceiver	1	Amazon	4.63
MDF Sealer	500ml	Amazon	7.85
Matt Black Spray Paint	600ml	Amazon	5.99
Miscellaneous		University	N/A

Total	**£ 109.6745**